AMENDMENTS TO THE TITLE:

Please replace the title to read as follows:

--FUEL INJECTION APPARATUS INCLUDING DEVICE FOR SUPPRESSING PRESSURE WAVES IN RESERVOIR INJECTION SYSTEMS--

AMENDMENTS TO THE SPECIFICATION:

Page 1, please add the following new paragraphs before paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 USC 371 application of PCT/DE 03/01999 filed on June 16, 2003.

[0000.6] BACKGROUND OF THE INVENTION

Please replace paragraph [0001] with the following amended paragraph:

[0001] ~~**Prior Art**~~ Field of the Invention

Please add the following new paragraph after paragraph [0001]:

[0001.4] This invention is directed to a device for suppressing pressure waves in reservoir injection system for an internal combustion engine.

Please add the following new paragraph after paragraph [0001.4]:

[0001.6] Description of the Prior Art

Please delete paragraph [0003].

Please replace paragraph [0005] with the following amended paragraph:

[0005] German Patent Disclosure DE 199 10 970 A1 discloses a fuel injection apparatus~~.~~ ~~**The fuel injection apparatus has**~~ having a booster unit, located between a pressure reservoir and a nozzle chamber, whose pressure chamber communicates with the nozzle chamber via a pressure line. A bypass line connected to the pressure reservoir ~~**is also provided. The**~~

~~bypass line~~ communicates directly with the pressure line. The bypass line can be used for a pressurized injection and is located parallel to the pressure chamber, so that regardless of the motion and position of a displaceable pressure medium in the pressure booster unit, the bypass line is passable. This embodiment offers the capability of meterable preinjection with low tolerances, by means of a slight or in other words unboosted injection pressure. By switching over between injection pressures, a flexible postinjection or a plurality of postinjections at high or low injection pressure can be realized.

Page 2, please replace paragraph [0006] with the following amended paragraph:

[0006] The triggering of a pressure booster produces a pressure fluctuation in the line between the pressure booster and the high-pressure reservoir, which results in an unwanted course of the injection pressure. During the injection, large quantities of fuel are drawn from the high-pressure reservoir. The resultant injection pressure course is characterized by a pronounced pressure maximum and an ensuing pressure drop toward the end of injection. This injection pressure course leads to poorer ~~the~~ emissions in self-igniting internal combustion engines and high peak loads on the components. The resultant pressure elevation is chronologically limited and is inadequate for the injection times required for utility vehicles, for instance, so that toward the end of injection, an unwanted pressure drop occurs. By means of a throttle associated with the high- pressure reservoir, the pressure wave can indeed be suppressed during the injection, but a pressure drop then occurs at the throttle, and as a result the attainable injection pressure and efficiency of the fuel injection system are still reduced.

Please replace paragraph [0007] with the following amended paragraph:

[0007] ~~Summary of the Invention~~ SUMMARY OF THE INVENTION

Please replace paragraph [0008] with the following amended paragraph:

[0008] With the compensation device ~~proposed~~ according to the invention between a high-pressure reservoir and a fuel injector, the pressure fluctuations that occur when fuel is withdrawn from the high-pressure reservoir can be reduced. The compensation device eliminates a pressure ~~disappearance~~ <u>drop</u> that occurs at the onset of an injection event, and it prevents a pressure drop both during injection and in injection phases that follow the injection. The injection pressure and the system efficiency of the fuel injection system are unimpaired by the compensation device. Upon triggering of a pressure booster of a fuel injector, or triggering of a fuel injector, the abrupt withdrawal of a quantity <u>of fuel</u> causes an underpressure wave, which travels from the fuel injector or pressure booster over the line to the high-pressure reservoir. The underpressure wave is reflected, at the end of the line toward the high-pressure reservoir, in the form of an overpressure wave, which can be utilized to increase the injection pressure level at the fuel injector. This superelevation of pressure is chronologically limited, however, and decreases again toward the end of the injection phase. Particularly in self-igniting internal combustion engines used in utility vehicles, because of the longer injection time, the pressure drop toward the end of the injection phase worsens emissions considerably.

Page 3, please replace paragraph [0009] with the following amended paragraph:

[0009] With the compensation device, which is received in the line system between the high-pressure reservoir (common rail) and the fuel injector - whether it is embodied with or without a pressure booster - the pressure fluctuation can be broken down, but a pressure drop toward the end of the injection phase or at the onset of the subsequent injections can also be avoided. This is attained by providing that <u>at</u> the onset of injection, a throttled connection

exists between the high-pressure line and the fuel injector and serves to break down the pressure fluctuations, while after a delay that is required for the break down of the pressure fluctuation, an unthrottled connection between the high-pressure reservoir and the fuel injector, or the pressure booster of the fuel injector, is opened. Thus in the injection phase, once the pressure fluctuation has been broken down, the high fuel pressure prevailing in the high-pressure reservoir is also present at the fuel injector, or at the pressure booster of the fuel injector. Thus not only can peak loads on the component, in terms of the stresses occurring upon pressure fluctuations, be avoided, but a pressure drop toward the end of the injection phase or at the onset of subsequent injections can be suppressed, which very favorably influences the emissions of self-igniting internal combustion engines. The throttle cross section between the line and the high-pressure source or high-pressure reservoir is designed such that only slight reflection, if any, of the underpressure wave at the end of the line occurs.

Page 4, please replace paragraph [0010] with the following amended paragraph:

[0010] ~~Drawing~~ BRIEF DESCRIPTION OF THE DRAWINGS

Please replace paragraph [0011] with the following amended paragraph:

[0011] The invention is described in further detail below, in conjunction with the ~~drawing.~~ drawings, in which:

Please delete paragraph [0012].

Please replace paragraph [0013] with the following amended paragraph:

[0013] Fig. 1[[,]] schematically shows a first ~~variant~~ embodiment of the compensation device proposed according to the invention, with throttle restrictions located outside a compensation element; and

Please replace paragraph [0014] with the following amended paragraph:

[0014] Fig. 2[[,]] shows a further ~~variant~~ embodiment of the compensation device proposed according to the invention, in which throttle restrictions are integrated with the compensation element.

Please replace paragraph [0015] with the following amended paragraph:

[0015] ~~Variant Embodiments~~

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Please replace paragraph [0016] with the following amended paragraph:

[0016] Fig. 1 shows a first ~~variant~~ embodiment of the compensation device ~~proposed~~ for suppressing pressure waves in a fuel injection apparatus according to the invention, in which the throttle restrictions are located outside the compensation device. In this embodiment, a fuel injection system 1 includes a fuel tank 2, which is filled with fuel 3. From the fuel tank 2, the fuel 3 is pumped via a fuel pump 4. The fuel 3 enters the fuel pump 4 at a low-pressure side 5 and leaves the fuel pump 4 at a high-pressure side 6. By means of the fuel pump 4, the fuel 3 is delivered to a high-pressure reservoir 7 (common rail), in which fuel pressures of up to 16 bar prevail. On the outside of the high-pressure reservoir 7, high-pressure line connections 8 are located, in a number corresponding to the number of cylinders of the self-igniting engine to be supplied with fuel. Via each of the high-pressure connections 8 schematically shown in Fig. 1, fuel at high pressure is delivered to one high-pressure line 27, which extends from the high-pressure reservoir 7 to a pressure booster 30 or to a fuel injector 40.

Please delete paragraph [0017].

Page 5, please replace paragraph [0018] with the following amended paragraph:

[0018] Although variant embodiments of the compensation device proposed according to the invention are described below that are used in fuel injectors 40 with a pressure booster 30, the compensation device described in further detail below can also be employed with fuel injectors that do not include any pressure booster. The compensation device proposed according to the invention is used in fuel injectors with a pressure booster 30 in which~~, and in injection,~~ an especially high volumetric flow of fuel out of the reservoir occurs <u>during injection</u>. Conversely, it is also possible to use the compensation device proposed according to the invention in fuel injectors without a pressure booster that ~~have~~ <u>deliver</u> high injection quantities.

Please replace paragraph [0019] with the following amended paragraph:

[0019] A compensation device 9 proposed according to the invention is integrated with the high-pressure line 27 that extends from each high-pressure line connection 8 of the high-pressure reservoir 7 to the fuel injector 40, or to a fuel injector with an associated pressure booster 30. In the first exemplary embodiment, ~~shown in Fig. 1, of a compensation device 9,~~ the compensation device 9 includes a housing 28. A compensation element 11 embodied in pistonlike fashion is located movably inside the housing 28. The compensation element has a first face end 13 and a second face end 14. The pistonlike compensation element 11 is prestressed by a prestressing spring 15 that acts inside the housing 28 on the second face end 14 of the pistonlike compensation element 11. The prestressing spring 15 is braced on the face end of the housing 28 diametrically opposite the second face end 14. In the region of this face end <u>of housing 28</u>, a stop element may be located for the second face end 14 of the pistonlike compensation element 11. The prestressing spring 15 is received inside a differential pressure chamber 29 of the housing 28. ~~A further, second throttle restriction~~

~~20 located outside the housing 28 is associated with the differential pressure chamber 29 of the housing 28 and discharges into the high-pressure line 27.~~ A first throttle restriction 19, ~~also~~ located outside the housing 28, is furthermore located in the high-pressure line 27 between the high-pressure reservoir 7 and the pressure booster 30. <u>A second throttle restriction 20 located outside the housing 28 is associated with the differential pressure chamber 29 of the housing 28 and discharges into the high-pressure line 27 downstream of throttle 19.</u>

Page 6, please replace paragraph [0022] with the following amended paragraph:

[0022] Downstream of both the first throttle restriction 19 received in the high-pressure line 27 and of the outlet 17, the compensation device 9 may include a throttling segment, which is identified by reference numeral 22. As indicated by the arrow in Fig. 1, the fuel at high pressure, stored in the high-pressure reservoir 7, flows from the compensation device 9 via the high-pressure line 27 to a pressure booster 30. The pressure booster 30 includes a pistonlike booster element 31 acted upon by a spring. The pistonlike booster element 31 acts on a high-pressure chamber 34. The pressure booster 30 furthermore includes a work chamber 32~~, identified by reference numeral 32,~~ and a differential pressure chamber 33. A differential pressure chamber throttle 36 precedes the differential pressure chamber 33 of the pressure booster 30. Connected parallel to the pressure booster 30, which is actuatable via a 2/2-way valve <u>35</u> that can for instance be embodied as a magnet valve, is a bypass line 37, which includes a check valve 38. The actuation of the pressure booster 30 is effected by means of a pressure relief of the differential pressure chamber 33 of the pressure booster 30 upon switching of the 2/2-way valve 35. If this valve is connected to a return 52 that discharges into the fuel tank 2, then <u>fuel</u> flows out of the differential pressure chamber 33, in

which a spring element acting on the pistonlike booster element 31 may be located, into the return 52. The pistonlike booster element 31 thereupon moves into the high-pressure chamber 34. As a result, fuel is pumped into a further pressure line 39, which changes over in the region of the fuel injector 40 into a nozzle inlet 49. The pressure level produced by the pressure booster 30 in its high-pressure chamber 34 exceeds the pressure level which prevails inside the high-pressure reservoir 7 that is acted upon by the fuel pump 4.

Page 8, please replace paragraph [0026] with the following amended paragraph:

[0026] The triggering of the pressure booster 30 is effected via the 2/2-way valve 35; the triggering of the fuel injector 40 is effected by actuation of the switching valve 45. To assure an elevated fuel pressure, that is, a fuel pressure which is above the fuel level prevailing in the high-pressure reservoir 7, the pressure booster 30 may be triggered slightly earlier than the fuel injector 40 in terms of the onset of injection. Upon triggering of the pressure booster 30, an underpressure wave occurs in the high-pressure line 27 between the high-pressure reservoir 7 and the pressure booster 30, because a greater fuel volume suddenly flows out of the high-pressure line 27. A reflection of the underpressure wave that occurs upon the onset of injection at the end, toward the high-pressure reservoir 7, of the high-pressure line 27 is suppressed by the first throttle restriction 19, which in the first exemplary embodiment of the compensation device 9 proposed according to the invention is located outside the housing 28. However, since the first throttle restriction 19 by itself would lead an excessively great pressure drop during the injection, a pressure difference becomes operative at the pistonlike compensation element 11 of the compensation device 9 when the slide 21 is closed. The compensation chamber 10, by way of which the first face end 13 of the pistonlike compensation element 11 is acted upon, is connected parallel to the first throttle restriction

19. Because of the pressure drop at the first throttle restriction 19 and because of the pressure prevailing ~~via~~ the at the inlet 16 ~~in~~ and the high-pressure reservoir 7, the pistonlike compensation element 11 is moved in the opening direction, counter to the action of the prestressing spring 15. Once a stroke length 18 in the opening direction has been overcome, the slide 21 that is formed by the housing 28 and a top region of the pistonlike compensation element 11 opens, and as a result a slide opening 23 is uncovered. The opening speed of the pistonlike compensation element 11 is adjusted by the cross section of the second throttle restriction 20 located outside the differential pressure chamber 29. By way of the dimensioning of the second throttle restriction 20, a delay in uncovering the slide opening 23 can be attained. The length of this delay is adjusted such that the reflection of the underpressure wave is avoided. If the pistonlike compensation element 11 uncovers the slide opening 23 once the stroke length 18 has been overcome, then a larger flow cross section is opened up between the high-pressure line 27 and the high-pressure reservoir 7. Because of this, in subsequent injection phases, no pressure loss occurs at the first throttle restriction 19. To stabilize the opening phase or in other words the response phase of the pistonlike compensation element 11, the compensation device 9 may include a throttling segment 22, which in terms of the inflow direction of the fuel with respect to the pressure booster 30, can be downstream of the first throttle restriction 19 and can be embodied either outside or inside the compensation device 9. Accordingly, at the onset of injection and immediately after the injection, there is a throttled connection between the high-pressure line 27 and the high-pressure reservoir 7, via the first throttle restriction 19, while after a length of delay that can be adjusted by means of the dimensioning of the second throttle restriction 20, there is an unthrottled connection between the high-pressure reservoir 7 and the high-pressure line 27 toward the pressure booster 30, via the slide opening 23 that is now in the opened position.

Page 10, please replace paragraph [0028] with the following amended paragraph:

[0028] Unlike the first exemplary embodiment, shown in Fig. 1, of the compensation device 9 proposed, in the exemplary embodiment shown in Fig. 2 both the first throttle restriction 19 and the second throttle restriction 20 are integrated with the pistonlike compensation element 11. The pistonlike compensation element 11 has a first face end 13 and a second face end 14. The second face end 14 is engaged by a prestressing spring 15, which is braced on the side of the housing 28 diametrically opposite the second face end 14. The housing 28 surrounds the compensation element 11. By means of the compensation element 11, the housing 28 is divided into the compensation chamber 10 and the differential pressure chamber 29. The stop 12, which can be embodied annularly, for the first face end 13 of the pistonlike compensation element 11 is let into the compensation chamber 10. At the inlet 16, the compensation chamber 10 is acted upon directly via the high-pressure line connection 8 of the high-pressure reservoir 7 by fuel that is at high pressure.

Page 11, please replace paragraph [0011] with the following amended paragraph:

[0029] The pistonlike compensation element 11, in the exemplary embodiment shown in Fig. 2, is penetrated by a conduit 24, inside of which both the first throttle restriction 19 and the ~~further,~~ second throttle restriction 20 are embodied. The conduit 24 represents a flow connection between the compensation chamber 10 and the differential pressure chamber 29 of the compensation device 9. Beginning at the conduit 24, a branch 25 extends that discharges in an annular chamber 26 embodied on the circumferential face of the pistonlike compensation element 11. The length of the annular chamber 26 at the circumferential face of the pistonlike compensation element 11 is equivalent to the axial length - relative to the housing 28 - of the slide opening 23 on the housing 28. Reference numeral 18 indicates the

stroke length that must initially be overcome by the pistonlike compensation element 11 before an unthrottled connection is created between the high-pressure reservoir 7 and the high-pressure line 27. The slide opening 23 represents the outlet 17 of the housing 28 of the compensation device 9.

Please replace paragraph [0031] with the following amended paragraph:

[0031] From the high-pressure chamber 34 of the pressure booster 30, a further high-pressure line 39 extends to the fuel injector 40. On the end of the fuel injector 40 toward the combustion chamber, the further high-pressure line 39 changes over into the nozzle chamber inlet 49. Via the further high-pressure line 39, the control chamber 41 and the nozzle chamber 48 are ~~is~~ acted upon ~~directly by fuel via the inlet throttle 42 and the nozzle chamber 48, and this~~ by fuel which ~~is~~ - in comparison to the pressure level of the high-pressure reservoir 7 - is at a ~~still~~ further-elevated pressure. The fuel at ~~still-~~further elevated pressure flows via the inlet throttle 42 into the control chamber 41, which can be pressure-relieved via the outlet throttle 43. For pressure relief of the control chamber 41 - and thus for actuation of the injection valve member 44 of the fuel injector 40 - the actuation of the switching valve 45 of the outlet throttle 43 is effected, which valve can be embodied as a magnet valve and likewise communicates, via a return line 52, with the fuel tank 2 of the fuel injection system 1.

Page 13, please replace paragraph [0035] with the following amended paragraph:

[0035] Upon triggering of the pressure booster 30, a pressure fluctuation occurs in the high-pressure line 27 between the pressure booster 30 and the high-pressure reservoir 7. By means of the compensation device 9 proposed according to the invention, a reflection of the underpressure wave on the end of the high-pressure line 27 pointing toward the high-pressure

reservoir 7 (common rail) is suppressed by means of the first throttle restriction 19 integrated with the pistonlike compensation element 11. With the pressure booster 30 triggered, fuel flows out of the compensation chamber 10 via the throttle restriction 19 and the branch 25 into the annular chamber 26 <u>and</u> into the high-pressure line 27. Because of the resultant pressure drop at the throttle 19, a pressure difference is created between the compensation chamber 10 and the differential pressure chamber 29. Via the high-pressure line connection 8 of the high-pressure reservoir 7, which connection acts on the inlet 16 of the compensation chamber 10, the pressure level that prevails inside the high-pressure reservoir 7 acts on the first face end 13 of the pistonlike compensation element 11. The slide 21, formed by the top region of the pistonlike compensation element 11 and the wall of the housing 28 of the compensation device 9, is initially closed. Because of the higher pressure inside the compensation chamber 10, which pressure acts on the first face end 13 of the pistonlike compensation element 11, the pistonlike compensation element 11 is displaced in the opening direction, counter to the prestressing spring 15. The opening speed at which the pistonlike compensation element 11 moves inside the housing 28 is determined by the second throttle restriction 20, also located in the conduit 24. Once the stroke length identified by reference numeral 18 is overcome, uncovering of the slide opening 23 is effected, the result being an unthrottled connection between the high-pressure line 27 to the pressure booster 30 and the high-pressure reservoir 7 (common rail). The opening speed of the pistonlike compensation element 11, which speed can be controlled by the dimensioning of the second throttle restriction 20 inside the pistonlike compensation element 11, makes it possible to manufacture an unthrottled connection between the high-pressure line 27 and the high-pressure reservoir 7 only once the reflection of the underpressure wave has been cancelled by

the first throttle restriction 19. As a result, in the ensuing injection phases, no pressure loss occurs at the first throttle restriction 19.

Page 14, please replace paragraph [0036] with the following amended paragraph:

[0036] With the exemplary embodiment of the compensation device 9 proposed according to the invention and shown in Fig. 2 as well, upon the onset of an injection a throttled connection is established between the high-pressure line 27 and the high-pressure reservoir ~~27~~ 7, via the first throttle position 19 that is integrated with the pistonlike compensation element 11. After a delay, the length of which can be adjusted by the dimensioning of the second throttle restriction 20, an unthrottled connection occurs between the high-pressure reservoir 7 and the high-pressure line 27 via the opened slide 21, or in other words as a result of the uncovering of the slide opening 23 in the housing 28, via the compensation chamber 10, by way of which the pressure booster 30 of the fuel injector 40 is acted upon by fuel that is at high pressure.

Page 15, please add the following new paragraph after paragraph [0037]:

[0038] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Please delete pages 16 and 17.